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# UNITED STATES DEPARTMENT OF AGRICULTURE

## DEPARTMENT CIRCULAR 411

Washington, D. C.

September, 1927

### THE RELATION OF INSECTS TO SLASH DISPOSAL

Prepared by the Division of Forest Insect Investigations, Bureau of Entomology<sup>1</sup>

#### CONTENTS

	Page		Page
Slash a factor in forest protection.....	1	Pine slash—Continued.....	
Few species of trees involved.....	3	Monterey pine in California.....	9
Pine slash.....	4	The southern pines.....	9
White pine in the Northeast.....	4	Spruce slash.....	10
Red pine and white pine in the Great Lakes		Spruce in the Northeast.....	10
region.....	4	Spruce in the Great Lakes region.....	10
Western white pine in the northern Rocky		Engelmann spruce in the Rocky Mountain	
Mountain region.....	5	region.....	10
Sugar pine in the Pacific coast region.....	6	Douglas fir slash.....	10
Western yellow pine.....	6	Conclusions.....	11
Jeffrey pine in California.....	8	Literature cited.....	12
Lodgepole pine.....	8		

#### SLASH A FACTOR IN FOREST PROTECTION

Does slash from cutting operations increase the insect menace to living timber? Many times this question has been asked by foresters and timbermen, but there has been little uniformity in the answers. Considerable confusion has arisen as a result, and a great diversity of opinion is found concerning the influence of slash upon insect outbreaks.

Two widely divergent opinions are held by professional forest entomologists in North America. In Canada, Swaine (10, p. 18; 11, p. 762; 12, p. 25; 13, p. 47; 14, p. 231; 15, p. 346)<sup>2</sup> and Hopping (6, 7) advocate on entomological grounds the necessity of slash disposal as a phase of forest protection. Workers in this country, Graham (2, p. 447), for example, almost unanimously take the opposite viewpoint, that under present economic conditions slash disposal can not be justified on entomological grounds. Chamberlin (1, p. 23), however,

<sup>1</sup> This circular was prepared by entomologists and collaborators of the Division of Forest Insect Investigations. Those primarily responsible for the information contained in the regional statements are as follows: F. C. Craighead, northeastern and southeastern forest regions; S. A. Graham, Lake States region; J. C. Evenden, northern Rocky Mountain region; W. D. Edmonston and F. C. Craighead, southern Rocky Mountain region; J. E. Patterson, north Pacific region; J. M. Miller, H. E. Burke, and H. L. Person, California region. F. P. Keen and F. C. Craighead are largely responsible for assembling the paper as a whole. In making reference to this circular it is to be understood that it is a product of joint authorship, as explained in the foregoing.

<sup>2</sup> Figures in italic in parentheses refer to "Literature cited," p. 12.



recommends burning slash of western yellow pine for the control of bark beetles. In England, Munro (8, p. 27), entomologist of the forestry commission, also recommends burning slash for control of bark beetles. It is fully realized, however, that broad statements applying indiscriminately to all forested regions are out of the question; the problem varies with each forest, region, and type. Not only must the species of tree and the character of the slash be considered but the various species of insects that may be involved must be taken into account.

It is recognized that, under special conditions, slash disposal or seasonal timing of cutting operations is advantageous. Such cases are referred to in the general text.

Hopkins discusses this question in many of his papers. His general conclusions are adequately supported by all the detailed investigations so far conducted by the Division of Forest Insect Investigations. As early as 1899 (3, p. 23) he called attention to the wasteful methods of lumbering in the Northwest and the attractive breeding places for forest insects provided by the scarred trunks and the débris left on the ground. Ten years later, in his monograph, (4, p. 25-26, 48), he suggests that the cutting of living timber for commercial purposes may offer favorable conditions for the multiplication of some of the species, although in some cases it may serve as a protection to living timber, and suggests burning the slash after it has attracted beetles away from the living trees. In one of his later papers on forest entomology (5, p. 8) he broadly summarizes his opinions as follows:

Since the problem of slash disposal is on the program of this meeting and, since it is pretty generally considered by foresters and some entomologists that slash is an insect hazard to the living timber, I want to say that the results of more than thirty years of observations and some detailed study of the problem indicate that as a rule, it is not. As in all rules, there are, of course, exceptions to this one. There are a few cases as related to certain types of forests, time of year, and cases of sporadic cutting, where the slash is dangerous, not so much from the insects that breed in the tops, logs, and stumps, as that it serves to attract the tree-killing insects to the locality and from thus being concentrated they attack and kill the living timber. Continued logging operations, after they are once started within a given area, provide continuous breeding places for the insects and their natural enemies and thus the slash serves as a protection to the living timber.

The entomologists of the Division of Forest Insect Investigations feel that a paper setting forth what is now known about the entomological effect of slash would help to clear the situation and stimulate more careful observation and compilation of further and needed data. In this, as in most scientific problems, the last word can never be said, and much investigative work is still needed to clear up many phases of the slash problem. However, considerable work has already been done, and certain tentative conclusions are presented in this circular.

There are hundreds of species of insects which breed in the slash of forest trees, but few of these are capable of doing much injury to living trees. They attack the base, the trunk, the tops, the limbs, or the twigs of mature standing trees; others emerge from slash and attack seedlings, saplings, and poles.

In addition to this, slash has a very strong attractive influence which may result in bringing thousands of insects into the general slash area with a resultant varying damage to living timber.



The direct result of insect attack upon the slash itself is beneficial because the insects aid in bringing about decomposition. In this circular the direct influence of insects upon twigs, limbs, and tops can be ignored and only the role of slash need be considered in (1) supplying breeding material for insects which emerge and kill mature standing timber or seedlings, saplings, and poles, and (2) attracting insects from the surrounding forest and concentrating them in the vicinity of the slash, where they kill living trees.

In general, the insects with which this discussion is concerned breed in the same parts of a fallen tree as of a living tree. Insects which attack the base of standing trees breed in stumps, those attacking the main trunk breed in cull logs, and those attacking limbs and twigs breed in the limbs and twigs composing the smaller portions of slash. There are, however, some important exceptions to this rule, such as certain species of *Ips*.

Probably the heaviest losses of all are attributable to the effect of slash in attracting beetles from the surrounding territory and concentrating them in the vicinity, where they are able to do greater damage to the standing timber than if their attacks had been scattered over a wider area.

This attractive influence has been noted many times. The felling of trap trees<sup>3</sup> has often concentrated attacks on adjacent healthy trees, even in some cases in which the felled trap tree has not been attacked. The beetle population is usually attracted to fire-scorched areas, even though the beetles are often unable to breed successfully in the trees weakened by fire. It is also usually attracted to places where heavy windfalls have occurred or to trees that have been broken down by snow.

It is evident that this class of damage can not be minimized through slash disposal. In fact, burning the slash in the summer, which is the flight period of the beetles, may even increase the attractive influence and bring about a still greater concentration.

#### FEW SPECIES OF TREES INVOLVED

The problem can be further simplified by limiting the discussion to such trees as are subject to primary damage from slash-breeding insects. Relatively few trees are thus involved.

All hardwoods can be eliminated from the discussion, as practically no insects which breed in hardwood slash are of importance as tree killers. Among the conifers, the slash of fir (*Abies*), larch (*Larix*), redwood (*Sequoia*), hemlock (*Tsuga*), cypress (*Cupressus*, *Taxodium*), cedar (*Thuja*, *Libocedrus*, *Chamaecyparis*), and juniper (*Juniperus*) either breeds insects of very little significance as tree killers, or the trees killed are so few or of so little value as to be of small economic importance.

As a result of these eliminations the problem in the United States, viewed from an economic standpoint under present forestry practices, resolves itself into a consideration of slash from pine (*Pinus*), spruce (*Picea*), and Douglas fir (*Pseudotsuga*). Each of these three groups will be taken up in sequence.

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<sup>3</sup> Living trees girdled or felled at the proper time to attract the flying beetles to them and away from healthy trees.



## PINE SLASH

The pines suffer more than any other group from the attack of bark beetles. It is not surprising, therefore, that pine slash should be viewed with the greatest suspicion as a forest menace. Upon study, however, the danger loses much of its alarming aspect.

## WHITE PINE IN THE NORTHEAST

The only really serious bark-beetle enemy of the white pine (*Pinus strobus*) which breeds in slash in the Northeast is the Pales weevil (*Hyllobius pales* Herbst). Studies by Peirson (9) indicate not only that this beetle breeds in stumps and cull logs but that the adult is also strongly attracted into slash areas for the purpose of feeding. It kills great quantities of small reproduction by gnawing off the bark until girdling results, and is frequently the limiting factor in obtaining white-pine regeneration.

No satisfactory method of control has yet been devised. Burning the bark of cull logs and thoroughly charring the stumps, or peeling the bark of logs and stumps (both of which are difficult and expensive processes), may lessen the damage to some extent, but will have no effect in lessening the attractive influence of the slash, which is, after all, probably the greatest source of danger. R. T. Fisher, in his experimental silviculture on the Harvard forest, has found that the only practical methods of preventing serious losses are (1) obtaining such an abundance of reproduction through reproduction cuttings that there are still enough seedlings left to produce a stand after the destruction wrought by the weevil, and (2) clear cutting, and subsequent planting after an interval of three years.

## RED PINE AND WHITE PINE IN THE GREAT LAKES REGION

Graham (2) reports that insect species that normally breed in the slash of the red pine (*Pinus resinosa*) and white pine (*P. strobus*) in the Great Lakes region have seldom been observed attacking or killing healthy trees. The insects responsible for the few exceptions to this rule are all found breeding in the stumps and larger parts of the slash.

The bark beetle *Dendroctonus valens* Lec. May occasionally kill trees, and is one of the most common of the species that breed in fresh pine stumps. It is almost never found breeding in parts of the tree more than 6 or 8 feet above the ground. All recorded cases of injury caused by this beetle to a standing tree have been associated with the attractive influence of logging operations, windfalls, fires, or logs in storage.

Several species of *Ips* occasionally kill trees and these, like the *Dendroctonus* beetles, usually breed most abundantly in the larger parts of the slash. The most common offenders of this group are *Ips pini* Say, a primary pest of red and white pines, and *I. calligraphus* Germar, which breeds in white pine. In the light of present knowledge it is safe to say that in the Lake States only the larger parts of the trees constituting pine slash have any entomological significance so far as living standing trees are concerned. Just how important an entomological factor these parts are can not be said, but it is certain that the stumps provide the most favorable breeding places.



The ordinary method of slash disposal, by burning, destroys only the small, entomologically innocuous parts of the slash, and leaves the parts most favorable for insect breeding. Any method of slash disposal that will reduce the number of insects must take care of the larger material. Even burning slash piled over stumps does not as a rule sufficiently char the stump to prevent subsequent insect infestation. Thorough charring can be accomplished only by keeping the fire close to the sides of the stump throughout the process of burning. Thorough charring of stumps is too expensive to be practical. Barking is cheaper, but must be carried down to the mineral soil if satisfactory results are to be expected.

Unpublished results of experiments in Minnesota indicate that heavy shade is unfavorable to most potentially injurious insect species. In one experiment, piling the small parts of the slash over the stumps very materially reduced the infestation. This experiment was on a small scale and only about 20 stumps were used, but the results were very clear cut. Pairs of stumps close together were selected; one of each pair was covered with the smaller parts of the slash, the other stump being left uncovered. The uncovered stumps were found to contain an average of 40 mother tunnels of *Dendroctonus valens* per stump, whereas the covered stumps averaged only 4 each.

From the data at hand the writers are forced to conclude that slash burning in the Lake States is unnecessary from the entomological point of view. Covering the stumps and larger pieces of the slash with the smaller pieces promises satisfactory results at a minimum cost.

#### WESTERN WHITE PINE IN THE NORTHERN ROCKY MOUNTAIN REGION

The most serious insect enemy of the western white pine (*Pinus monticola*) is the bark beetle *Dendroctonus monticolae* Hopk. This species breeds successfully in cull logs from logging operations, and also kills living trees. General observations by Evenden indicate that during continuous logging operations the progeny of such beetles as breed in the cull logs are absorbed in the new material made available, so that little damage results to standing trees. Because of the value of this timber species very close utilization is practiced, and ordinarily only a very small quantity of slash over 6 inches in diameter is left in the woods. Occasionally, however, where a certain quantity of such material is left in the woods at the close of a logging operation, and no fresh material is provided, the insects which emerge attack and kill standing trees in the vicinity, or seed trees left on the area occupied by the slash.

As these beetles do not breed in the smaller tops and limbs the present methods of brush disposal by burning can have no possible effect upon their number. And because of the close utilization of the larger material other measures for preventing injury by insects do not ordinarily appear to be justified. If, however, for any reason, any quantity of large slash material is left in the woods and no fresh material is provided to absorb the emerging broods, then as a protective measure the bark should be peeled from the infested cull logs before the beetles emerge; otherwise some damage to standing trees may result.

Two smaller species of insects (*Pityogenes carinulatus* Lec. and *P. knechteli* Sw.) breed in the smaller material from the tops. Occasionally they breed in sufficient numbers to attack and kill small



white pine reproduction. These cases are of such sporadic occurrence and of such minor importance that they are negligible.

#### SUGAR PINE IN THE PACIFIC COAST REGION

The bark beetle *Dendroctonus monticolae* Hopk. is also the principal enemy of the sugar pine (*Pinus lambertiana*) in the forests of the Pacific coast. As in white pine, it breeds both in cull logs and in standing trees. This species of pine is not, however, subject to heavy epidemics of infestation such as occur in yellow pine, and no heavy killings have yet been traced to the slash of logging operations. On the Yawkey tract, near Fort Klamath, Oreg., in 1922 and 1923, Patterson, Keen, and Hauge noted a considerable increase in the numbers of standing trees killed shortly after many trees were blown down by a high wind. In general, the considerations applying to utilization and slash disposal in the case of white pine apply to this species as well.

#### WESTERN YELLOW PINE

In California and Oregon the western pine beetle, *Dendroctonus brevicomis* Lec., is the principal insect enemy of the western yellow pine (*Pinus ponderosa*). Besides attacking living trees this insect breeds in the trunks of fallen trees which are more than 6 inches in diameter.

In some cases it has been noted that heavy losses by insects have followed logging operations, whereas in other cases logging areas have been singularly exempt from such injury. Keen reports that on the southern Oregon-northern California project two of the cleanest areas were adjacent to areas where continuous logging had been in progress for several years; that one heavily infested area was adjacent to a logged area where operations had ceased; and that in one unit a reduction of 60 per cent in infestation, equal to the best obtained by artificial control work, followed the beginning of logging operations on adjacent ground.

To determine if possible the reason for this condition, Person carried out some investigations in southern Oregon and central California. Eleven logging slash areas, two road slash areas, and one group of windfalls were studied. By bark counts made on 459 pieces of slash it was found that the average number of attacking beetles per square foot was 9.8, and the number of beetles emerging, 16. Similar studies were made by Patterson in southern Oregon. Five logging areas, one windfall area, and 24 miles of road slash were studied; the last named involved the examination of 1,425 pieces of slash, including the examination of 1 square foot of bark on each of 1,075 trees. Bark counts in this material gave 15.6 beetles per square foot attacking and 19 beetles per square foot emerging. Bark counts made on hundreds of standing trees near by showed an average attack of 23 *Dendroctonus* beetles per square foot, with 54 beetles emerging. It is evident that the attack and emergence on slash material is far below that for standing trees. In all of these studies checks on the surrounding infestation were made before, during, and for several years after the laying down of the slash.

Usually the first effect of the slash was to increase the infestation in standing trees in the vicinity. In every case, however, this increase occurred simultaneously with the attack on the slash, instead of following the emergence of the beetles breeding in the slash.



Numerous observations made by forest entomologists in the Western States point conclusively to the fact that the western pine beetle is strongly attracted to the vicinity of slash material, trees scorched by fire, trap trees, and windfalls. As long ago as 1906, Webb (17, p. 80) pointed out that storm-felled and lightning-struck western yellow pines became centers of infestation by this insect. If a concentration of the beetles is brought about through the presence of some such material, they not only attack this material but go into the standing living trees in the immediate vicinity.

From these investigations the conclusion is reached that the destruction of standing trees by insects, consequent upon logging operations in adjacent territory, is not caused by the breeding up of insects in the slash, but by the concentration in the slash of beetles from the surrounding territory, and the failure of the slash to absorb them all. This strong attractive influence can not well be avoided.

Since the western pine beetle breeds only in the slash material more than 6 inches in diameter, such as cull logs and butts, the present methods of slash disposal can be of little avail in reducing the numbers of beetles. Neither can the very strong attractive influence of the slash be avoided. The best way, therefore, to avoid injury to neighboring standing trees is to supply continuously a quantity of logs to absorb the broods of beetles, and, if necessary, to reduce, through artificial control, the total population of beetles on the area.

Several species of *Ips* (*I. emarginatus* Lec., *I. oregoni* Eich., *I. confusus* Lec., etc.) breed in the smaller pieces of the slash material as well as in some of the larger pieces. When they become sufficiently numerous, if there is a shortage of slash, they may kill young trees, and the tops and limbs of larger trees. This damage is very sporadic, and usually follows the interruption of logging operations in the summer months. Keen has reported three small areas on the North Warner division of the Modoc National Forest, in California, where species of *Ips* have caused heavy losses of reproduction after the cessation of logging operations in the summer months. The conditions were complicated by extremely dry weather. Usually a supply of fresh slash, continuously laid down during the summer months, will absorb all of these beetles and prevent injury to neighboring living trees.

In general it may be said that, in the light of present information, no special methods of slash disposal need be recommended to avoid insect damage to western yellow pine, except in the case of sporadic cutting or when logging operations cease. In such cases infested slash material should be destroyed before the broods of insects emerge. The same general considerations apply to western yellow pine in the northern Rocky Mountain region.

In the southern Rocky Mountain and Colorado Plateau regions the Black Hills beetle (*Dendroctonus ponderosae* Hopk.) is the principal insect enemy of the western yellow pine (*Pinus ponderosa* var. *scopulorum*). Edmonston has reported that in Colorado the forest areas showing least infestation are always those adjacent to places where logging operations are in progress, particularly where the operations have been continuous for several years. Several officials of the Forest Service have reported similar observations. Recent studies by Craighead, Blackman, and Keen in the Kaibab National Forest in Arizona indicate that the felled logs and culls act as traps for the



beetles during the flight period. When the material is sawn, practically all the beetles are destroyed, and in the logs that are left in the woods during the winter a very high mortality of beetles occurs, so that the emerging beetles are much fewer than those attacking. At the same time the cull logs and tops furnish good breeding material for certain borers (*Acanthocinus*) and predatory species which are detrimental to the development of the *Dendroctonus* broods. As these enemies increase with this abundance of breeding material they tend to concentrate on any standing trees which are attacked, and thus hold the infestation at a minimum. Under these conditions it is doubtful whether disposal of the larger slash would not in fact be more injurious than beneficial to neighboring standing timber.

In both the Rocky Mountain and the Pacific regions *Dendroctonus valens* Lec. breeds in stumps and butt logs, and to a limited extent it attacks the base of live trees. This injury is not often severe enough to warrant the expense of special control methods, such as piling brush over stumps, prompt removal of logs, and barking of cull logs.

In Arizona, New Mexico, and south of the Colorado Plateau, some outstanding cases of losses to reproduction resulting from insects breeding in slash have been called to our attention. Craighead reports that two species of *Ips* were found breeding in cull logs and larger tops of western yellow pine on timber sales. The spring generation of beetles is confined to this felled material, whereas the summer generations attack and kill pine reproduction in clumps of from one-tenth to 1 acre. At some places these repeated attacks have materially thinned out the stands of second growth. Modifications of logging operations will be necessary to prevent these losses.

#### JEFFREY PINE IN CALIFORNIA

The Jeffrey pine beetle (*Dendroctonus jeffreyi* Hopk.), although often a very destructive insect in living Jeffrey pine (*Pinus jeffreyi*) in California, is only weakly attracted to the slash of this tree. This species and other bark beetles, such as *Ips*, breed very freely in windfalls and large pieces of slash material. On large windfall areas they may occasionally breed up to the point where they become very destructive to adjacent full-grown timber, saplings, poles, and the top of mature trees. Such epidemics are, however, characteristically sporadic, and their control is not economically feasible at the present time except in cases where high timber values are involved. As far as injury by insects is concerned Jeffrey pine slash is usually of but slight importance.

#### LODGEPOLE PINE

The mountain pine beetle (*Dendroctonus monticolae* Hopk.) is a very serious enemy of lodgepole pine (*Pinus murrayana*), often killing hundreds and even thousands of acres of the standing timber. Here is another case, and a very striking one, of an insect which is strongly attracted to the vicinity of logging or clearing operations, yet rarely attacks the felled trees. Clearings for summer homes or hotels have often brought about such a slaughter of lodgepole pines in the vicinity as to mar the beauty of the site. Even control operations are not immune, and in one instance such a heavy concentration of beetles followed control cutting as entirely to wipe out the effect of the work.



Nevertheless, a felled tree is rarely attacked. Here, again, it is obvious that slash disposal does not reduce the number of beetles, and the concentration caused by the slash appears to be unavoidable.

Another lodgepole pine insect (*Dendroctonus murrayanae* Hopk.) has habits similar to those of *D. valens* Lec., discussed under yellow pine. Evenden has found this species of economic importance in crosstie operations in Wyoming. Breeding readily in the stumps, it subsequently attacks the bases of the larger standing trees not included in the sales. Repeated attacks of this kind weaken the tree to such an extent that it succumbs to the attack of other bark beetles on the bole.

#### MONTEREY PINE IN CALIFORNIA

Several serious outbreaks of Ips on the Monterey pine (*Pinus radiata*) near Monterey, Calif., have been accounted for as caused by wood cutting and clearing, where the wood has been left piled in the forest. Other factors, however, enter into this problem, since similar cutting in other years has produced no epidemics. The turpentine beetle (*Dendroctonus valens* Lec.), which breeds usually in stumps, often becomes primary in its attack upon standing trees of this species.

Because of the value of the Monterey pine as an ornamental and shade tree, special precautions in slash disposal may well be taken to help minimize insect damage to it, which occasionally becomes serious.

#### THE SOUTHERN PINES

The southern pine beetle (*Dendroctonus frontalis* Zimm.) and three species of Ips (*I. calligraphus* Germ., *I. avulsus* Eichh., and *I. grandicollis* Eichh.) are the most important pine insects of the South. The first species mentioned rarely attacks anything but living trees, whereas the three species of Ips are more commonly found in tops, cull logs, and stumps than in standing pines. All these species are so intimately associated in the destruction of living trees that it is impossible to consider them separately. On the other hand, the infrequency with which the southern pine beetle attacks slash, cull logs, or wind-blown trees immediately eliminates it as an argument for the disposal of such material.

Very few reports of dying pine timber in the South that can be associated with slash as a factor have been called to the writers' attention, and extensive observations by several entomologists have not revealed any striking examples. In fact, experimental cuttings of timber, conducted throughout the year with the express purpose of furnishing the breeding material for these insects, have utterly failed to produce attacks in the surrounding standing trees. Nevertheless, there are many examples which show that these species are all strongly attracted to areas where cutting is being carried on in the summer. If sufficient material is on the ground they invariably attack it, and occasionally small quantities of neighboring living timber are killed. For example, a freshly sawn pile of lumber, brought to a home site for building purposes, attracted to that vicinity a sufficient number of these insects to kill a number of trees adjacent to the pile.

It is therefore reasonable to conclude that slash serving as breeding material for these insects is not a menace, but that because of the attraction which it exerts on them local logging or clearing operations in the summer should be avoided.

## SPRUCE SLASH

### SPRUCE IN THE NORTHEAST

Several species of bark beetles breed in the stumps, logs, or tops of spruce (*Picea canadensis*, *P. rubens* and *P. mariana*), and attack and kill living trees.

The eastern spruce beetle (*Dendroctonus piceaperda* Hopk.) is a particularly destructive species which breeds in stumps and cull logs. It has destroyed large areas of mature spruce forests in the past, and active epidemics are now in progress in Canada, even in second-growth stands. Recent observations by Craighead indicate that it is most destructive only when accompanied by one or more species of Ips, which combine with it and attack the upper stems.

Several species of Ips (*I. borealis* Sw., *I. perturbatus* Eichh., and *I. chagnoni* Sw.) have in two cases been observed by Craighead breeding in slash, and in the following year attacking and killing near-by living trees. From these, however, scanty broods developed, and in the third year the outbreaks completely died out.

Special methods of slash disposal do not appear to be justified from the entomological standpoint, but cull logs and larger débris should not be left in the woods (16, p. 85). The increasingly closer utilization practiced in this region with the development of the pulp industry will undoubtedly tend to minimize such losses.

### SPRUCE IN THE GREAT LAKES REGION

There is no specific evidence to prove that spruce slash in the Lake States has any entomological significance, although there is justification for suspecting that the larger pieces may be of some importance. Most of the spruce (*Picea canadensis* and *P. mariana*) cut in this region finds its way to pulp mills, a fact which makes for close utilization. A comparatively small quantity of material suitable for the breeding of potentially injurious insects is left in the woods after logging operations.

### ENGELMANN SPRUCE IN THE ROCKY MOUNTAIN REGION

The Engelmann spruce beetle (*Dendroctonus engelmanni* Hopk.) breeds in the culls and stumps of the Engelmann spruce (*Picea engelmanni*) and also attacks and kills living trees. The small quantity of timber of this species which is now being cut makes of small importance the danger from this source. No opportunity has yet presented itself for the study of the effect of extensive logging on this insect.

### DOUGLAS FIR SLASH

There are several insects which breed in the large pieces of slash of Douglas fir (*Pseudotsuga taxifolia*) and are capable of killing living trees, though they rarely do so. The more important of these are *Dendroctonus pseudotsugae* Hopk., *Scolytus unispinosus* Lec., and *Melanophila drummondi* Kirby.

In the region along the Pacific coast reports on observations of the death of Douglas fir from the attack of insects that breed in slash are so infrequent that they can be disregarded. This fact may be due to



the extensive and continuous character of the logging operations. Recently, however, reports from the British Columbia Forest Service indicate heavy killing of Douglas fir adjacent to certain logging operations on the coast of British Columbia.

In the northern Rocky Mountain region conditions are somewhat different. The Douglas fir beetle (*Dendroctonus pseudotsugae* Hopk.) is apparently much more aggressive in these less humid sections. In recent years it has been causing considerable damage, and coming more and more to be considered a serious insect. Evenden believes that several local outbreaks under his observation are clearly attributable to slash which has resulted from logging operations, construction of rustic buildings, spruce-budworm defoliation (resulting in the death of many trees), or windfalls.

Two small bark beetles, *Scolytus unispinosus* Lec., and *Pseudosyllensinus nebulosus* (Lec.) occasionally multiply in slash, and when no more material is available they cause damage to reproduction and to young trees.

The question of the destruction of Douglas fir by insects needs much more thorough study and more systematic observations before any conclusions can be ventured.

### CONCLUSIONS

The outstanding conclusions which have been reached to date in regard to the entomological aspect of slash disposal are given here.

As far as is now known, pine, spruce, and Douglas fir are the only species of timber to which insects associated with slash are of any important economic significance.

Comparatively few species of insects are capable of adapting themselves to breeding in slash and killing living trees.

The great majority of the important tree-killing insects which attack slash breed largely in the cull logs and butts. It follows that the present methods of brush burning can have little influence on their control.

Where logging operations are continuous, and a constant supply of slash is provided, the potential danger from insects need cause no concern.

Slash attracts from the surrounding forests insects which often concentrate in standing timber in the vicinity of the cutting. No method of slash disposal will avoid this effect.

In special cases where the value of the surrounding timber is greatly enhanced, either from an æsthetic standpoint as a building site or for scientific purposes such as experimental thinnings in sample plots, extreme caution should be exercised in felling green timber. In such cases the attraction of the felled timber for insects is more important than its service as a breeding ground, and all such work should be done in the fall or winter, at least two months before the growing season.

A large number of insects of secondary importance breed in the twigs, limbs, and trunks of fallen trees, and sometimes become so numerous as to kill reproduction, pole stands, and occasionally even mature trees in the vicinity. Such outbreaks are, however, sporadic in nature and of short duration, and, under present economic conditions, do not warrant special methods of slash disposal.



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